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PATENT ABSTRACTS OF JAPAN

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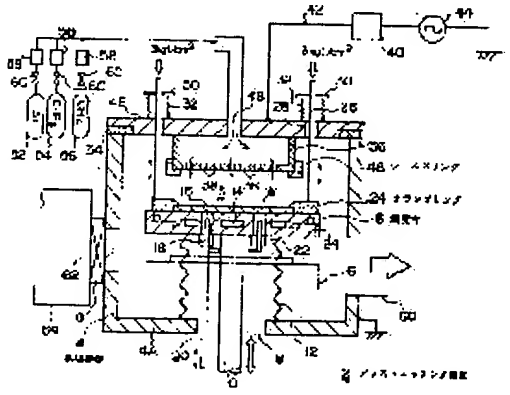
(54) PLASMA TREATMENT DEVICE

(57)Abstract:

PROBLEM TO BE SOLVED: To provide a plasma treatment device using a material which has a high plasma resistance and does not easily generate particles as consumable parts around electrodes.

SOLUTION: In a plasma treatment device performing plasma treatment to a workpiece mounted on a mounting stand 6 inside a treatment container 4 allowing vacuum izing, consumable parts 24, 46 provided inside the treatment container 4 are composed of a polycrystalline alumina quality sintered body with purity not less than 99.9% and bulk density 3.980 or more. Thereby, resistance to plasma is improved and close adhesion to a deposit is improved so as to make particles hard to come off.



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CLAIMS

[Claim(s)]
[Claim 1] Plasma-treatment equipment characterized by bulk specific gravity constituting the consumables prepared in the aforementioned processing container with 3.980 or more nature sintered compacts of a polycrystal alumina from 99.9% or more of purity in the plasma-treatment equipment which gives a plasma treatment to the processed field laid on the installation base within the processing container made possible by vacuum length.
[Claim 2] The aforementioned consumables are plasma-treatment equipment according to claim 1 characterized by being the focal ring which is arranged at the circumference section of the aforementioned installation base, and brings the electric field together in the installation side side of the aforementioned installation base.
[Claim 3] The aforementioned consumables are plasma-treatment equipment according to claim 1 characterized by being a clamp ring for making the aforementioned processed field hold on the aforementioned installation base.
[Claim 4] It is the plasma-treatment equipment according to claim 1 to 3 characterized by being the shield ring which the aforementioned installation base is made to counter, the up electrode is prepared in the aforementioned processor, and the aforementioned consumables are arranged at the circumference section of the aforementioned up electrode, and brings the electric field together in the front face of this up electrode.

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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[The technical field to which invention belongs] this invention relates to the plasma-treatment equipment which gives a plasma treatment to a semiconductor wafer etc.
[0002]
[Description of the Prior Art] Generally, by repeating and giving membrane formation, pattern etching, etc. by CVD etc. to a semiconductor wafer in the manufacture process of semiconductor devices, such as IC and LSI, a desired circuit element is formed and it goes. In case of processing of a wafer, according to the latest high density and the inclination of a raise in detailed, process conditions are also still severer and severe conditions are searched for about suppression of the particle which causes [big] the yield fall especially. Although a batch-type processor is used since a lot of wafers can be processed general at once about processing of a semiconductor wafer, since uniform processing becomes comparatively difficult, by batch processing, a single-wafer-processing processor, especially plasma-treatment equipment have attracted attention against this, as a wafer size diameter[of the macrostomia]-izes to 8 inches or 12 inches.
[0003] In plasma-treatment equipment, a semiconductor wafer is laid on the installation base in the processing container made possible by vacuum length, for example, and this is mechanically fixed on an installation base by the clamp ring and the electrostatic chuck made from an alumina using a Coulomb force. And by impressing RF power etc. between the up electrodes which were made to counter the installation base and this which make a lower electrode serve a double purpose, and have been arranged, a plasma will be stood under the vacuum ambient atmosphere, for example, etching gas etc. will be passed, and etching processing will be performed to the oxide on the front face of a wafer etc.
[0004] By the way, although the above-mentioned clamp ring and the focal ring made from a quartz arranged among the circumference section of an installation base so that the RF electric field may concentrate on a wafer side, when an electrostatic chuck is used without using a clamp ring are prepared in a processing container The sediment which consists of a polymer of CF system which occurs in case the spatter of them is carried out to a plasma since these parts of the electrode circumference are always exposed to a plasma into a process, it exhausts little by little or the oxide on the front face of a wafer is etched into these parts adheres gradually.
[0005] If it separates and it falls from parts, since it becomes a particle, and will adhere to a wafer side and it will become the cause of a yield fall, if the addition time of a process becomes above to some extent, this affix will wash by picking out the concerned parts from a processing container, and will remove a sediment. Moreover, the parts itself will be exchanged for another new parts, if these parts are exhausted to some extent above and become thin. Although the shield ring made from a quartz which centralizes the RF electric field on an electrode side side like the function of the above-mentioned focal ring is prepared in the circumference section of the up electrode which counters with an installation base and is arranged etc., it exhausts among it similarly about this part, and a sediment adheres to it.
[0006]

[Problem(s) to be Solved by the Invention] By the way, although the problem was not produced so much in the former whose design design of a semiconductor device is not so severe, if a high density and high detailed-ization progress like recently and submicron order is demanded as line breadth, the demand to a particle also becomes much more severe, and it is asked for the parts which a particle more seldom generates. furthermore, if open the inside of a processing container wide and there is nothing to ** of washing or a parts replacement, since it will not become, the part and a process are stopped and it has become the cause of a fall of a throughput, and the endurance over a plasma needed to be raised this invention is originated paying attention to the above troubles that this should be solved effectively. The purpose of this invention has high plasma-proof nature as consumables of the electrode circumference, and is to offer the plasma-treatment equipment using the material which seldom generates a particle, either.

[0007]

[Means for Solving the Problem] In order that this invention may solve the above-mentioned trouble, in the plasma-treatment equipment which gives a plasma treatment to the processed field laid on the installation base within the processing container made possible by vacuum length, it is 99.9% or more of purity, and bulk specific gravity constitutes the consumables prepared in the aforementioned processing container with 3.980 or more nature sintered compacts of a polycrystal alumina.

[0008] Thus, by constituting, the rigidity of the consumables which consist of a nature sintered compact of a polycrystal alumina, and a mechanical strength improve, and plasma-proof nature increases, and the adhesion to a sediment can also be raised. therefore -- for example, since CF system polymer affix generated at the time of etching of an oxide comes to seldom separate, the part and the particle to generate can be suppressed, and it is enabled to lengthen a running term until it needs washing Furthermore, as a result of plasma-proof nature's increasing, the amount of tabescence of consumables decreases and it is enabled to lengthen this life.

[0009] Although the parts which are arranged near the electrode and are easy to receive the spatter by the plasma as such consumables, for example, a focal ring, a clamp ring, the shield ring, etc. correspond, it is not limited to these. As applicable plasma-treatment equipment, a modality is not limited, for example, can be applied to parallel monotonous type plasma equipment, reactive-ion-etching (RIE) equipment, efficient consumer response (Electron Cyclotron Resonance) etching system, etc.

[0010]

[Embodiments of the Invention] Below, one example of the plasma-treatment equipment concerning this invention is explained with reference to an accompanying drawying. The block diagram showing the plasma-treatment equipment which drawing 1 requires for this invention, and the drawing 2 are plans showing the clamp ring used for the processor shown in drawing 1 . Here, an parallel monotonous type plasma etching system is explained for an example as plasma-treatment equipment. This plasma etching system 2 has the processing container 4 fabricated by aluminum in the shape of a barrel so that it may illustrate. This processing container 4 is grounded. in this interior The disc-like installation base 6 which consists of a conductive material, for example, aluminum, as a lower electrode Designation fixation is carried out at the upper limit of the rise-and-fall shaft 10 inserted through the opening 8 of the center section of container pars-basilaris-ossis-occipitalis 4A, and by carrying out the rise-and-fall drive of this rise-and-fall shaft 10 by the hoist style not to illustrate, it goes up or may have comes to down the above-mentioned installation base 6. For example, semiconductor wafer W is laid in the installation side which is a top of this installation base 6 as processed field.

[0011] It is airtightly connected through the metallic bellows 12 which was made possible by expansion and contraction as for the rear face of this installation base 6, and the circumference of the opening 8 of container pars-basilaris-ossis-occipitalis 4A, and rise and fall of the installation base 6 are permitted, holding the airtightness in the processing container 4. And the installation base 6 will be indirectly grounded through this bellows 12 and the processing container 4. The path-like cooling jacket 14 is formed in this installation base 6, and wafer W can be maintained now to desired temperature by passing a refrigerant to this. furthermore, two or more lifters [position / of the circumference section of this installation base 6] -- a hole 16 penetrates and prepares in the vertical orientation -- having -- **** --

this lifter -- a hole 16 is made to correspond and the wafer lifter pin 18 is arranged possible / rise and fall / in the vertical orientation The rise-and-fall move is attained for this wafer lifter pin 18 in one with the pin rise-and-fall rod 20 made possible by vertical movement through the pars-basilaris-ossis-occipitalis opening 8. It permits moving up and down, the metallic flexible bellows 22 being formed in the penetration section of this pin 18 between the rear faces of the installation base 6, and a pin 18 holding airtightness. Thus, by making a pin 18 fluctuate in the status that you made it located in the place which shows the installation base 6 to an alternate long and short dash line, wafer W is raised, or it has and lowers. Generally, such a wafer lifter pin 18 is made to correspond to the wafer periphery section, and is prepared three.

[0012] Moreover, it is made to correspond to the circumference section of this installation base 6, and the clamp ring 24 by which it is characterized [of this invention] as consumables is arranged in the upper part. As shown also in drawing 2 , this clamp ring 24 is fabricated with the path somewhat larger than the path of wafer W in the shape of a ring, among those a side edge edge can be formed along with the profile of wafer W, can lap with the periphery edge of wafer W slightly, and can push the circumference section now against an installation base side. Therefore, the fraction to which the inside edge of the clamp ring 24 contacts the edge of wafer W is fabricated by the cross-section right angle. And support fixation of this clamp ring 24 is carried out at the soffit of two or more support rods (4 [for example,]) 26 made from an alumina ceramic which penetrated the breakthrough 28 prepared in head lining 4B of a container 4, and hung. And it permits that the support rod 26 moves up and down by fixed stroke, the stopper 30 which regulates descent of the rod beyond it being formed in the fraction located up for a while rather than container head lining 4B of the support rod 26, forming the metallic flexible bellows 32 between this stopper 30 and container head lining 4B, and holding the airtightness in a container. And for example, the air actuator not to illustrate is formed in the upper part of this support rod 26, and each support rod 26 is turned caudad and it always energizes by the predetermined pressure, for example, the force of 3kgf/cm2.

[0013] Therefore, if press fixation of the circumference section is carried out on the installation base 6 with the clamp ring 24 by the pressure of 3kgf/cm2 and wafer W on the installation base 6 dropped the installation base 6, when the stopper 30 of the support rod 26 will reach head lining 4B, the clamp ring 24 will be left there and engagement of wafer W and the clamp ring 24 will separate from it. In addition, the so-called focal function to bring together the RF electric field other than the above-mentioned wafer hold function in an installation side side also has this clamp ring. Purity is 99.9% or more and, as for this clamp ring 24, bulk specific gravity is constituted by 3.980 or more nature sintered compacts of a polycrystal alumina. An alumina ceramics which is shown in JP,5-160240,A can be used for this nature sintered compact of an alumina. In this case, it is desirable to set up mean crystal grain within the limits of 10-100 micrometers. Thus, it is enabled to make asymmetry small, to raise a mechanical strength and plasma-proof nature, while internal pore can be lessened extremely, and to also raise the adhesion with a sediment by specifying mean crystal grain.

[0014] When the diameter of mean crystal grain is less than 10 micrometers, remains pore exists in the grain boundary, a fall of corrosion-resistant is caused or a possibility that the pollutant from the exterior may become easy to invade is in surface pore. If mean crystal grain exceeds 100 micrometers, a mechanical strength and plasma-proof nature will fall. Moreover, if the purity of an alumina is less than 99.9%, the chemical resistance at the time of wet washing using fluoric acid etc. will fall. In order to manufacture this clamp ring 24 as consumables, first, desirably, using 99.99% or more of high-purity-alumina raw material powder, addition mixture of the magnesia (MgO) as a growth retardant of unusual grain and the organic binder is carried out at this, and it fabricates in a clamp ring configuration. As the molding technique, a press forming, extrusion molding, injection molding, or a doctor blade method is taken. Temporary quenching of the obtained Plastic solid is carried out in the 900-1100-degree C atmospheric air of temperature, it disperses an organic additive, and is advanced to a baking process. In order to have a bad influence on the product after baking, the device which lessens contamination from each equipment, the ambient atmosphere, etc. as much as possible is required for impurity mixing at the process before baking.

[0015] Subsequently, in order to obtain a true-density sintered compact, in non-oxidizing atmospheres, such as the inside of a vacuum, and the hydrogen gas ambient atmosphere, a duration hold is carried out with the burning temperature of 1700-1850 degrees C, the temporary-quenching field is calcinated, and a product is completed. In hydrogen gas ambient-atmosphere baking, since the diffusion rate of hydrogen is large, issue of the pore in the second half of baking becomes easy, and pore is lost substantially. Moreover, vaporization of impurities, such as alkali metal, advances during baking, the impure amount of resources contained in raw material powder decreases, and high-grade-ization is promoted much more. Here, burning temperature and the holding time are suitably set up so that the diameter of mean crystal grain may be set to 10-100 micrometers. It returns to the drawing 1 and the drawing 2 , and head lining 4B of the processing container 4 is connected to the mainframe side of a container through the insulating member 34, the installation base 6 is made to counter this head lining 4B, and the shower head 36 of the shape of a thin container is formed. The nozzle 38 of the masses which turn to processing space S the raw gas and plasma gas which were introduced in this head 36, and are spouted is formed in the gas injection side of the inferior surface of tongue of this shower head 36.
[0016] A conductive material, for example, a front face, is formed of the aluminum by which alumite processing was carried out, it constitutes the up electrode, and is connected to RF generator 44 which generates a 13.56MHz RF through the feeder 42 which interposed the matching circuit 40 on the way, and this shower head 36 may have comes to impress high-frequency voltage. And in order to bring together the RF electric field generated in an up electrode in an inside electrode side, the cross-section [of L characters]-like shield ring 46 is formed in the soffit circumference section of this shower head 36 along with the hoop direction of the shower head 36 as consumables. It is making for this shield ring 46 to be constituted by the nature sintered compact of a polycrystal alumina of the same material as the aforementioned clamp ring 24, to raise plasma-proof nature, to raise the adhesion with a sediment moreover, and for this to separate, and to fall.
[0017] The gas introduction spool 50 is connected, this gas introduction spool 50 branches to a plurality, and the source 52 of Ar gas which stores Ar gas as plasma gas, and the sources 54 and 56 of etching gas which store the etching gas of CHF3 and CH4 as a raw gas are connected to the gas inlet 48 of this shower head 36, respectively. Each of these gas will be supplied, control of flow being carried out by the mass-flow controller 58 interposed on the way and the opening-and-closing valve 60. Moreover, a part of side attachment wall of the processing container 4 is made to correspond to the position which dropped the installation base 6, the wafer taking-out inlet 62 is established in it, and gate-valve G which was made possible by vacuum length and which opens for free passage and intercepts between load locks chamber 64, for example is prepared here, and the exhaust port 66 connected to the evacuation system which interposed the vacuum pump not to illustrate is formed in another side.
[0018] Next, the etching process performed using the equipment constituted as mentioned above is explained. First, in the status that the installation base 6 was dropped down [in the processing container 4] as shown in an alternate long and short dash line, unsettled semiconductor wafer W is introduced in the processing container 4 currently beforehand made by the vacua through the wafer taking-out inlet 62 from the load-lock-chamber 64 side, and is laid on the installation base 6. Next, by moving the rise-and-fall shaft 10 upwards, the installation base 6 is raised, the periphery section of wafer W is made to contact the clamp ring 24 hung possible [vertical movement], this is pushed up further, and wafer W is fixed in the clamp ring 24, for example, the energization force of 3kgf/cm2. And supplying plasma gas and etching gas of the specified quantity in the processing container 4 from the shower head 36, vacuum length of the interior is carried out, process ** is maintained, 13.56MHz high-frequency voltage is impressed between the installation bases 6 and up electrodes which are a lower electrode simultaneously, a plasma is stood to processing space S, and etching processing of the oxide film currently formed in the wafer front face is performed.
[0019] Whenever it performs etching processing by such plasma, the polymer of CF system which is exposed to a plasma, is exhausted although it is [every / whether to be small and], and occurs at the time of etching will deposit the shield ring, the consumables 24, for example, the clamp ring, of the electrode circumference, 46 little by little. Since the nature sintered compact of a polycrystal alumina

rigidity was high, was excellent in plasma-proof nature, and the adhesion with a sediment moreover excelled [sintered compact] in this example as a component of these consumables here is used and there is no sediment peeling omission easily, the long time of running to cleaning can be taken, and it is enabled to suppress occurrence of a particle as much as possible moreover. Moreover, since there are also few amounts of tabescence by the plasma, it enables them to lengthen the part and a duration of service and to carry out reinforcement. Thus, plasma-proof nature and a particle depressor effect can be raised simultaneously, and enhancement in the yield and enhancement in a throughput can be aimed at simultaneously.

[0020] Here, since it actually asked for the degree [exhausting / to a plasma], the result is explained with reference to the drawing 3 and the drawing 4 . Drawing 3 is a graph which shows configuration change of the initial configuration of the conventional clamp ring and the clamp ring after about 180 hours processing. Drawing 4 is a graph which shows configuration change of the configuration in early stages of the clamp ring of this invention and the clamp ring of about 270 hours after. Both curvilinear A shows an initial configuration, curvilinear B shows the configuration after about 180 hours processing, and curvilinear C shows the configuration after about 270 hours processing. the place which a measurement part is the wafer contact section of a clamp ring, and was measured four points at equal intervals to the ring hoop direction -- all -- abbreviation -- the same amount of tabescence was shown Tabescence of about a maximum of 0.25mm is received after processing of about 180 hours, and the spatter rate of consumables becomes an hour in about 1.36micrometers /so that clearly from the graph shown in drawing 3 .

[0021] On the other hand, in the case of the clamp ring of the nature sintered compact of a polycrystal alumina, after processing of about 270 hours, small, it is tabescence of about a maximum of 0.12mm, and the spatter rate of consumables becomes with an hour in about 0.44micrometers /so that clearly from the graph shown in drawing 4 . Therefore, in the case of this invention, as compared with elegance, the endurance over a plasma can be raised also about 3 times conventionally, and the good result is shown in it. Drawing 5 is a graph which shows transition of the increase in a particle when using the clamp ring of the time of using the clamp ring of a proior art and this invention. Before putting in and putting in the monitor wafer of a 8 inch size in a processing container every 5 hours the impression time of RF power in case of measurement, after putting in, it carried out, when the particle size on a wafer measured the number of particles of 0.2 micrometers or more. A particle control value is 30 pieces, and if this is reached, generally cleaning operation will enter. As for the process conditions at this time, for RF power, 1300W and a pressure is [the gap of 300mTorrs and processing space S of each flow rate of 9mm, and CHF3/CH4 / Ar gas] 30/30/600SCCM, respectively.

[0022] Although the impression time of RF power is the part of 25 hours, 50 hours, 80 hours, and 90 hours, and is over the particle control value in equipment conventionally and washing operation is required here so that clearly from this graph It becomes clear that the impression time of RF power is over the particle control value greatly for the first time in the part of abbreviation 115 - 130 hours in this invention equipment, and membrane formation separates very much, are hard coming to fall, and occurrence of a particle is suppressed. It is thought that this is because the adhesion of the nature sintered compact of a polycrystal alumina and a sediment improved. Moreover, in this invention equipment, it is thought that the ground which the big peak generated in the above-mentioned time zone is because the particle deposited until now separated and fell at a stretch and it fell on the wafer.

[0023] If it is in the example of equipment shown in drawing 1 , although the clamp ring 24 having the focal function of the RF electric field is formed as a means which carries out hold fixation of the wafer W on the installation base 6, it replaces with this and can apply also to the equipment which prepared the electrostatic chuck which carries out the adsorption hold of the wafer on an installation base by the Coulomb force. [redacted] is a block diagram showing such plasma-treatment equipment, attaches the same sign about the same fraction as the component shown in drawing 1 , and omits an explanation. That is, in this plasma-treatment equipment, the thin product made from a polyimide resin or the [redacted] made from a ceramic which embedded the [redacted] which becomes the interior from electric conduction plates, such as copper, is prepared in the top of the

installation base 6, and the adsorption hold of the wafer W is carried out by the Coulomb force which this electrostatic chuck 70 generates on this top. And the insulated lead wire 72 for electric supply is connected to this electrode for chucks 68, and this lead wire 72 is connected to the source 76 of a high voltage direct current which outputs the high-voltage-direct-current voltage for Coulomb-force occurrence through an open/close switch 74.

[0024] And the [redacted] of the shape of a ring as consumables is formed in the circumference section of the installation side of the installation base 6 so that it may approach and the periphery of wafer W may be surrounded, and the RF electric field are brought together in an installation side side. The nature sintered compact of a polycrystal alumina which is the same material as the previous clamp ring 24 (refer to the drawing 1) also constitutes this focal ring 78. Moreover, the endurance over a plasma can be similarly raised sharply with having explained previously by this, the adhesion with a sediment is raised, this can make to separate and the depressor effect of particle occurrence can be raised as a result.

[0025] In the above example, it does not pass over the structure of a clamp ring, the shield ring, and a focal ring for an example to only have been shown, and it is not limited to such structures. For example, as structure of a clamp ring or a focal ring, the nature sintered compact of a polycrystal alumina of this invention may be prepared inside in the shape of a ring, the conventional ring made from an alumina may be prepared in the outside, and you may make it the configuration made into the so-called double ring structure. Moreover, the thing of the structure prepared in the container side attachment wall which divides processing space as shield ring may be used. Furthermore, it is not limited to three parts described above as consumables, but anythings are applicable if it is the parts exchanged periodically or irregularly. Furthermore, it is not limited to what impressed high-frequency voltage to the up electrode, but can apply also to the thing of structure which impressed high-frequency voltage to a lower electrode or two electrodes. Moreover, the format of plasma-treatment equipment is also applicable not only to an parallel monotonous type but reactive-ion-etching (RIE) equipment, MERIE (Magnetical EnhancedRIE) equipment, efficient consumer response etching system, etc. Furthermore, as a process, it is applicable not only to etching but plasma spatter equipment, plasma ashing equipment, plasma CVD equipment, etc. Moreover, as processed field, it is not limited to a semiconductor wafer, for example, can apply to a glass substrate, LCD substrate, etc.

[0026]

[Effect of the Invention] As explained above, according to the plasma-treatment equipment of this invention, the operation effect which was excellent as follows can be demonstrated. Since bulk specific gravity used 3.980 or more nature sintered compacts of a polycrystal alumina at 99.9% or more of purity as consumables in the processing container which processes the processed field by the plasma, rigidity and a mechanical strength can be improved, the endurance over a plasma can be raised sharply, and this life can be prolonged sharply. Moreover, since it is making to raise the adhesion to the sediment generated within a processing container, and to separate this, occurrence of a particle can be suppressed sharply and the yield can be raised. Moreover, since a cleaning cycle can be lengthened as a result, the part and a throughput can also be raised.

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DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] It is the block diagram showing the plasma-treatment equipment concerning this invention.
[Drawing 2] It is the plan showing the clamp ring used for the processor shown in drawing 1 .
[Drawing 3] It is the graph which shows configuration change of the initial configuration of the conventional clamp ring and the clamp ring after about 180 hours processing.
[Drawing 4] It is the graph which shows configuration change of the configuration in early stages of the clamp ring of this invention and the clamp ring of about 270 hours after.
[Drawing 5] It is the graph which shows transition of the increase in a particle when using the clamp ring of the time of using the clamp ring of a proior art and this invention.
[Drawing 6] It is the block diagram showing the plasma-treatment equipment using the focal ring as consumables.
[Description of Notations]
2 Plasma Etching System (Plasma-Treatment Equipment)
4 Processing Container
6 Installation Base (Lower Electrode)
24 Clamp Ring (Consumables)
26 Support Rod
36 Shower Head (Up Electrode)
44 RF Generator
46 Shield Ring (Shield Ring)
70 Electrostatic Chuck
78 Focal Ring (Consumables)
W Semiconductor wafer (processed field)

[Translation done.]

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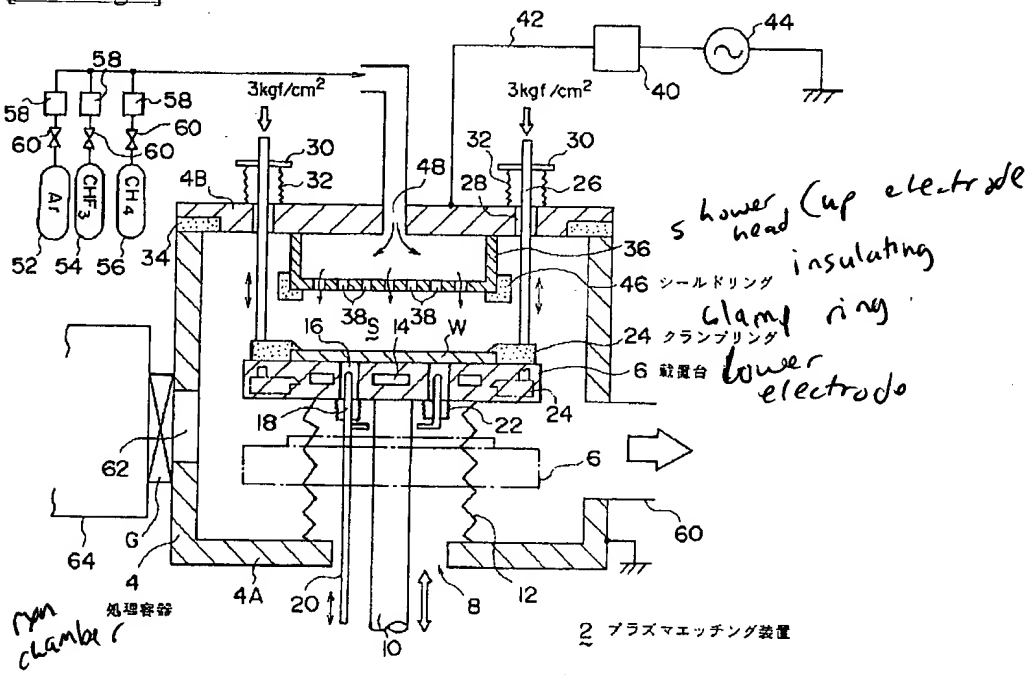
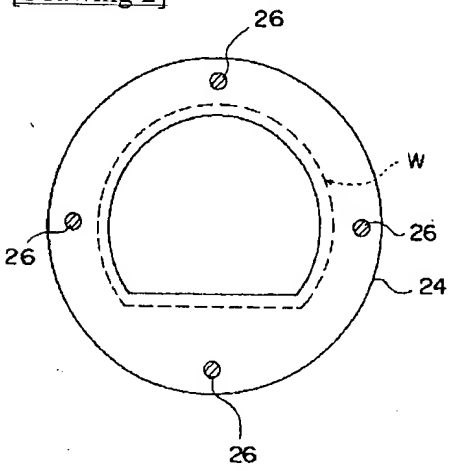
DRAWINGS

[Drawing 1]



[Drawing 2]



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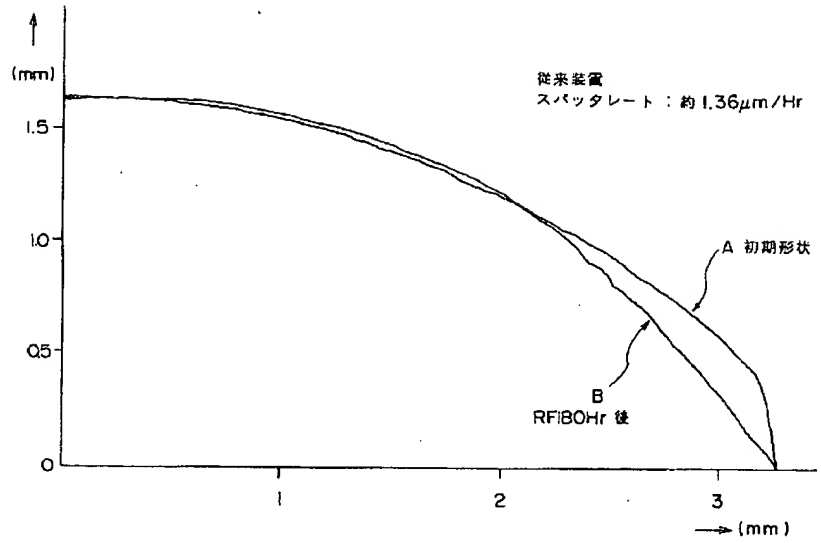

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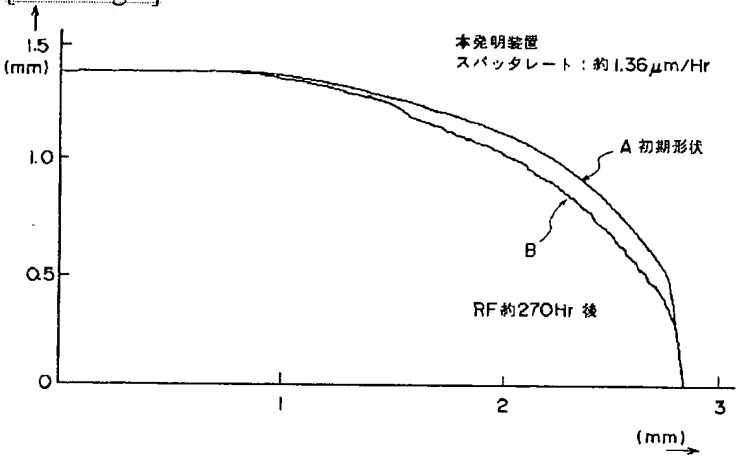
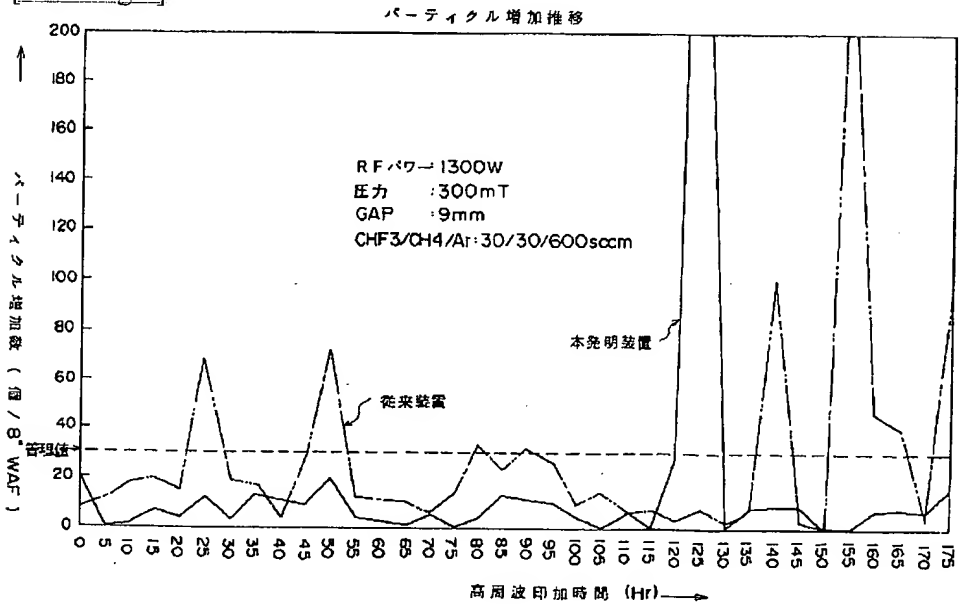
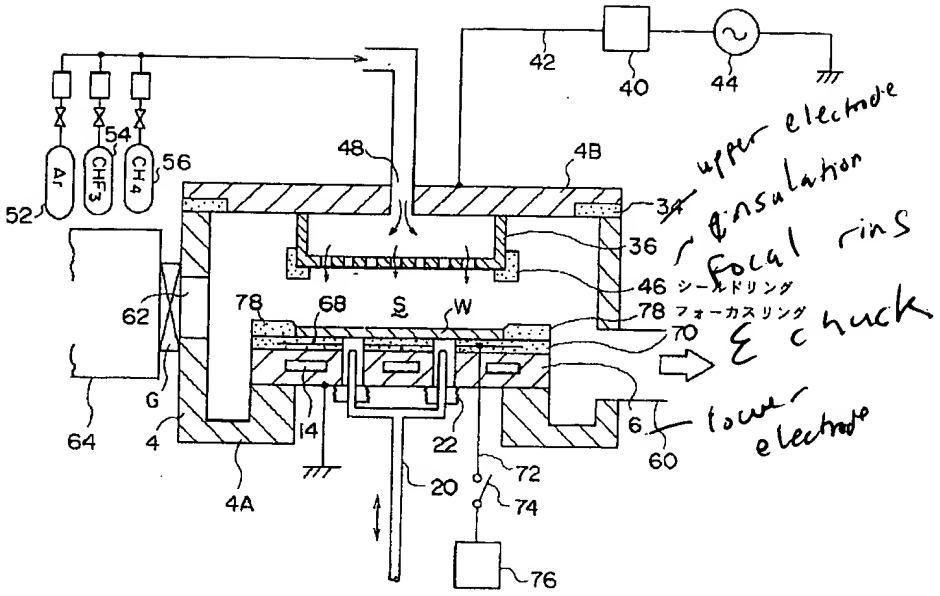


[Drawing 5]



[Drawing 6]



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